

Pedestrian Refuge Island Safety Audit

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INTRODUCTION

Public agencies have a growing awareness of the need to better accommodate the safety and security of pedestrians in the roadway environment. There are a number of features that aid pedestrians to cross major roads that are seeing more use as a result. The use of refuge islands on their own, or in conjunction with pedestrian crossovers, has been considered as a method of enhancing safety in the City of Toronto, Canada. Over the past 10 years, more than 60 islands have been implemented in Toronto and surrounding jurisdictions.

City of Toronto officials initiated a review of the operations of the islands to gain insight into design issues and safety implications, given that pedestrian refuge islands (PRI), and split pedestrian crossovers (SPXO) are becoming a more common element of the roadway. It has become important to document standard practices, deficiencies and the effectiveness of the islands. These practices and operational experiences will provide a basis for a comprehensive audit of the islands.

It is expected that the presence of the islands tends to encourage pedestrian crossing of major roads at locations other than at signalized intersections. The benefits of the islands in terms of the simplifying the crossing maneuver for pedestrians is weighed against a potentially more aggressive pedestrian behavior and likelihood of increases in pedestrian crossing activity and the resultant exposure to conflict with vehicles. This review was intended to identify under what conditions the implementation of islands is either problematic or beneficial.

CURRENT PRACTICES

Although the City of Toronto has approximately 1,800 signalized intersections, the demand for mid-block pedestrian crossing of major roads remains high. Factors contributing to the crossing demand include the frequency of transit stop locations, the presence of store front commercial development “main streets” on arterial roads, and major mid-block pedestrian generators (schools, parks).

While the two devices assist pedestrian crossing using an island within the roadway, PRIs and SPXOs have different rules of operation, and are implemented under different circumstances.

In Toronto, pedestrian refuge islands have been implemented in locations where there is sufficient pedestrian crossing demand and pedestrians show a pattern of difficulty in crossing, but where higher forms of traffic control are not appropriate given spacing or volume criteria. Pedestrian refuge islands have been typically implemented where pedestrian mid-block crossing volumes exceed 100 in 8 hours. Pedestrian refuge islands were initiated as a slab island to provide a waiting area in the centre of the roadway, typically within a two-way centre left turn lane. These islands evolved to include handrails and signage designed to encourage pedestrians to wait for a gap in the centre of the roadway. **Exhibit 1** illustrates a slab refuge island design

In Toronto, pedestrian crossovers had been implemented as a form of controlled pedestrian crossing on suburban arterial roads, however over time many of these roads have been widened, and speeds and volumes have increased significantly. Split pedestrian crossovers were introduced as a measure to retain the original purpose of PXOs, but allow pedestrians to cross one direction at a time. Split pedestrian crossovers are typically implemented as the conversion of PXOs at locations where the safety of the operation of the PXO has been raised as a concern. **Exhibit 2** illustrates a split pedestrian crossover.

Exhibit 1 – Pedestrian Refuge Island



Exhibit 2 – Split Pedestrian Crossover



the two forms of island have a common design, with a width of 6 feet and length of 36 feet and height of 6 inches. The railing is a standard design 3 ½ feet high and 19 feet long. Signage provided includes advance warning signage for vehicles, end signs on the island (hazard marker and keep right), and signage to direct pedestrians where to cross.

INTENT OF THE ISLAND AND OPERATIONAL BENEFITS

The design of the island with the use of the railings is intended to direct pedestrians to cross one direction of traffic and enter the island at one end, walk toward the traffic flow of the second direction and exit the far end of the island (see **Exhibit 3**). The benefit of this configuration is to:

- Concentrate pedestrian crossing activity,
- Encourage pedestrians to cross at the most visible locations, and
- Allow pedestrians the best view of on-coming traffic prior to the second stage of the crossing

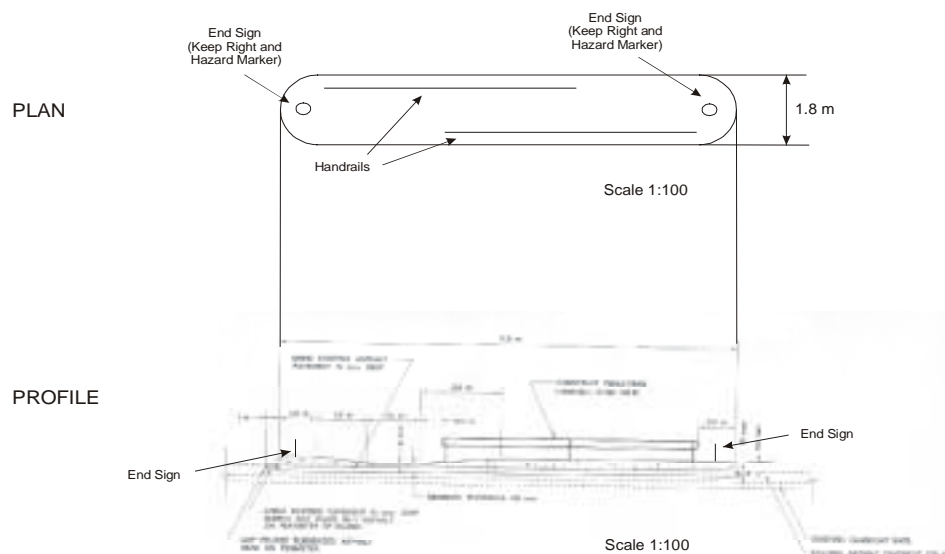
Over 80% of pedestrians observed crossing the street, used the islands as they were intended.

The use of a pedestrian refuge island will reduce pedestrian delay for crossing. For pedestrians to safely cross a four or five lane road at a normal walking speed (4 feet/second), a gap in traffic of 12 - 14 seconds is necessary to cross a typical 50-55 foot street based on random vehicle arrivals (HCM methodology). The gap required for elderly pedestrians is commonly higher. For roads with an hourly volume of 2,500 (AADT of 25,000), pedestrians may have to wait approximately 5 minutes for a suitable gap. Pedestrian refuge island permits a pedestrian to cross the two directions of traffic separately, requiring a 6 second gap at a time, for which pedestrians would typically wait less than 20 seconds on a road with an AADT of 25,000.

For split pedestrian crossovers the island creates two PXOs and allows the pedestrian to concern himself with ensuring that one direction of traffic stops rather than two before stepping off the curb. Pedestrians crossing the second direction of traffic are closer to the cone of sight of those drivers.

Random surveys of pedestrians using the pedestrian islands were conducted for the purpose of obtaining general public perception of the islands. Almost all pedestrians surveyed felt that the islands are convenient to use and added to their level of safety.

Exhibit 3 – Island Design



COLLISION HISTORY

An assessment of traffic collisions at 10 pedestrian islands within the City of Toronto were undertaken to determine what relationships may exist between the number of collisions and island characteristics. Sites were chosen that reflected typical locations for both SPXOs and PRIs. Collision data was compiled for a three year period.

The collision experience of the two forms of pedestrian accommodation was assessed separately to determine if there were differences in their safety experience. A comparison of collisions by these two forms of islands indicates that they do have different collision relationships.

The collision frequency per island was significantly higher for split pedestrian crossovers 14 over three years, than for pedestrian refuge islands 2 over three years. As a measure of the level of exposure the pedestrian volumes were approximately 3 times higher at SPXOs and vehicle volumes were approximately 2 times higher at the PRI locations. The SPXOs and PRIs also had different collision type and maneuver type characteristics.

Figure 1 outlines the collisions by collision type. **Figure 2** summarizes the collisions by impact type.

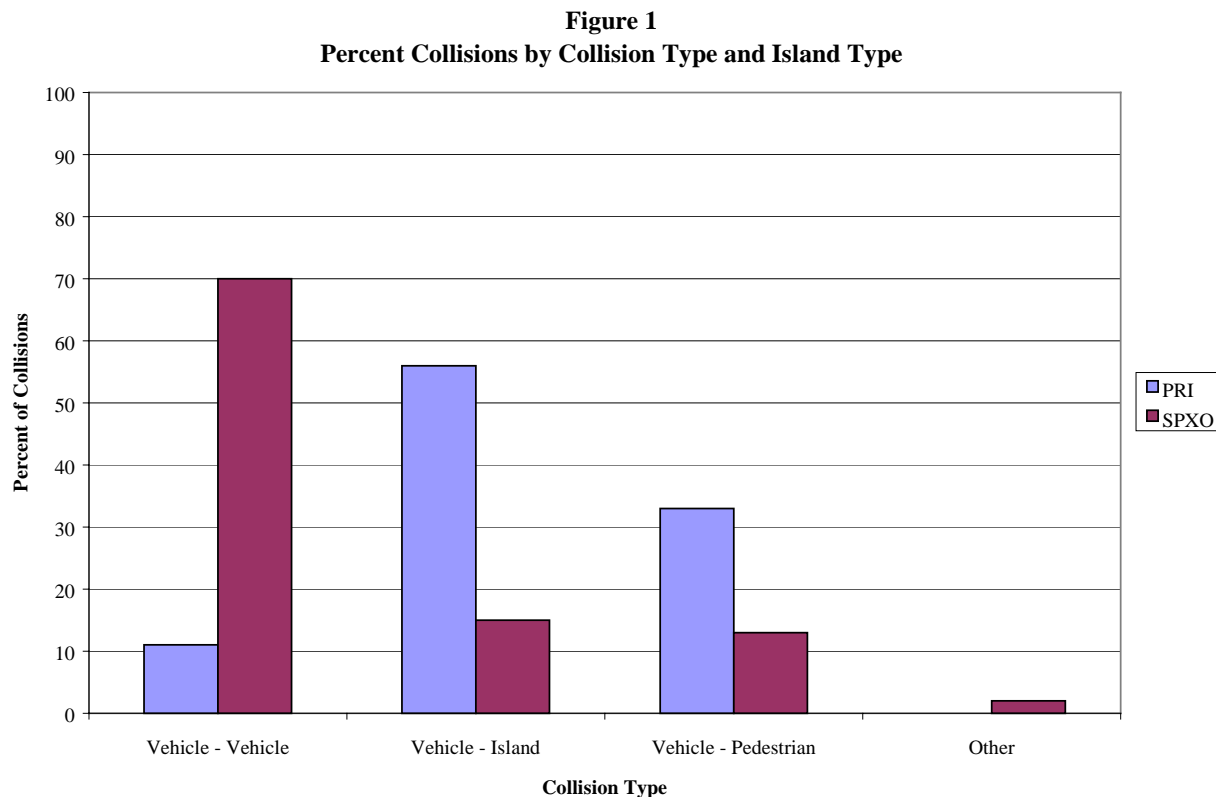
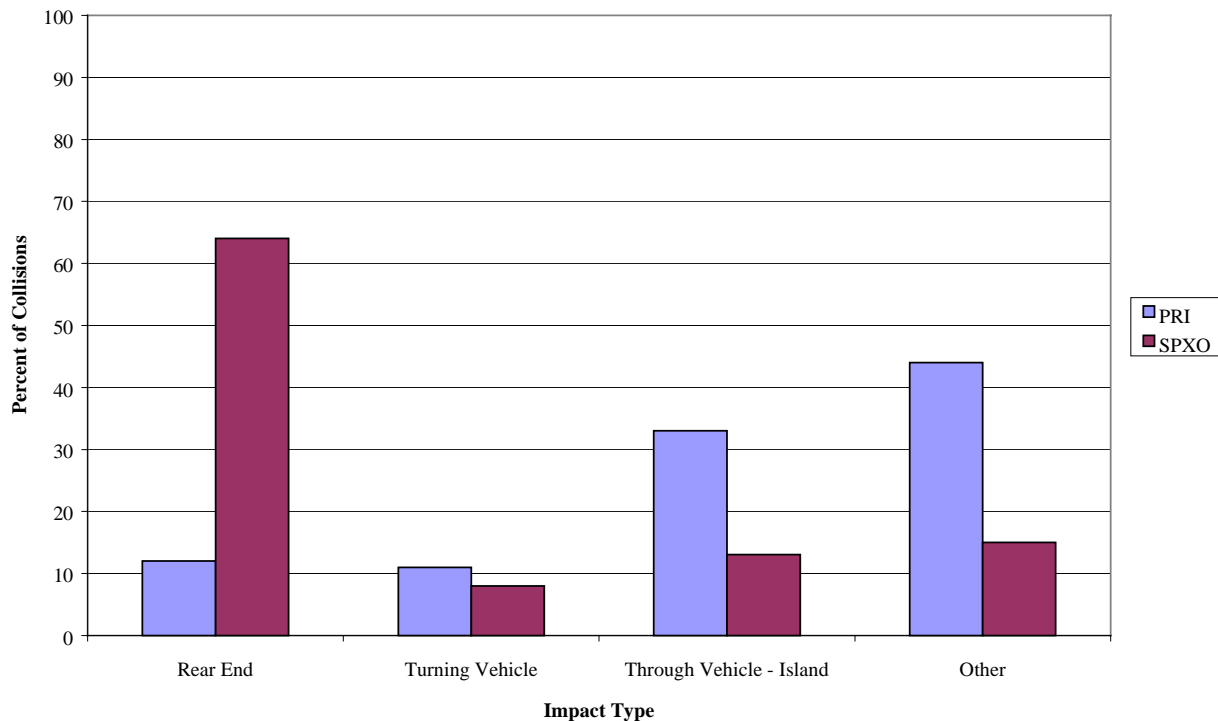


Figure 2
Percent Collisions by Impact Type and Island Type



A review of collisions by hour of the day indicated that 75% of the collisions occurred during daylight hours. Most pedestrian related collisions occurred during afternoon and early evening hours.

The vast majority of collisions that occurred at SPXOs involved vehicle-vehicle (64%) or vehicle-island collisions (19%). Between one and two vehicle island collisions are reported per island per year. Of the sites analysed, there was an average of 9 vehicle-vehicle collisions per SPXO or 3 per year. The non-uniform behavior of drivers in yielding to pedestrians may have contributed to this problem. Where pedestrians were involved in collisions at SPXOs, most involved turning vehicles and/or vehicles failing to yield the right of way.

At PRIs, reported vehicle-island and vehicle-pedestrian collisions each represented 44% of collisions. It appears as though lack of night visibility may have been a contributing factor for vehicle-island collisions at pedestrian refuge islands. All of the reported vehicle-island collisions for pedestrian refuge islands occurred at night. Where pedestrians were involved in collisions at PRIs, most involved pedestrians that stepped out onto the roadway without the roadway being clear or where there were insufficient gaps in traffic.

Pedestrians were not struck while standing on the island at either a SPXO or a PRI for those locations surveyed. For SPXO's, vehicle-island collisions were evenly distributed between day and night hours.

A comparison of collision experience before and after island implementation showed little change for most locations surveyed. One split pedestrian crossover location exhibited a

significant increase in collisions and one pedestrian refuge island location experienced a significant reduction in collisions.

HUMAN FACTORS CONSIDERATIONS

The potential for an incident involving pedestrian-vehicle collision is affected by:

- The pedestrian's ability to recognize the potential interaction with a vehicle and respond appropriately
- The driver's ability to recognize and react to the potential interaction with the pedestrian, the island, and surrounding vehicles

The road environment should be designed such that there is sufficient information for drivers and pedestrians to make rational decisions. There should be sufficient visibility between driver and pedestrian. And the rules of right of way should be clearly understood between pedestrians and all vehicles in the traffic stream. In recognition of these basic principles, the design of the roadway should take into consideration all roadway elements and how they contribute to likelihood and severity of collisions.

The design of the roadway can aid pedestrians, simplifying the judgement required in assessing gaps in traffic. The provision of a pedestrian refuge islands is intended to do just that, allowing the pedestrian to assess gaps in traffic in only one direction at a time. Road design guides vehicles through points of interaction with pedestrians. The roadway also provides information to the driver through formal (pavement markings, signs, and traffic control) and informal (alignment, roadside features, road geometry). Just as signs, road signs and pavement markings direct vehicles, drivers take cues on the roadway ahead from the consistency of the road alignment to that point or through the alignment of roadside features.

ROAD ENVIRONMENT

The road environment contributes to the ability of road users to recognize the interaction between drivers and pedestrians and act appropriately and safely. Vehicle speed and volume directly affects the ability of pedestrian to judge and appropriately use acceptable gaps in traffic at pedestrian refuge islands. The visual obstructions and distractions on the road and in the boulevard affect the driver's ability to recognize pedestrians crossing at split pedestrian crossovers.

As previously noted, for pedestrians to safely use the pedestrian refuge islands at a normal walking speed (4 feet/second), a gap in traffic of 6 seconds is necessary to cross half of a typical 50-55 foot street. Of the PRI sites investigated, vehicle volumes ranged from 25,00 to 35,000. AADT volumes in excess of 45,000 result in pedestrians waiting approximately 40 seconds for 6 second gaps during peak hours. Consideration should be given to vehicle volumes in excess of this level.

The ability of pedestrians to accurately judge gaps in traffic decreases as vehicle speed increases. Through surveys of users, most drivers did not feel comfortable stepping onto the roadway with vehicles closer than 200 feet away. The safe stopping sight distance of 200 feet equates to a speed of 35 mph. Of the PRI sites investigated, the 85th percentile speed was in excess of 40 mph.

The nature of the roadway itself contributes to the ability of drivers and pedestrians to act safely. Pedestrian islands are a link between pedestrian destinations and this link should extend beyond the provision of pedestrian facilities on the roadway. Pedestrian facilities should extend into the boulevard area and provide clear lines of sight between the pedestrian and driver with limited distractions. Vertical or horizontal curves where sight lines are limited compromise safety.

Similarly, on-road obstructions limit pedestrian and driver visibility. Parking and accesses should be limited in close proximity to the islands sufficient to maintain safe stopping distance. Far side bus stops are also recommended to limit the effects of buses blocking sight lines. Signs poles and other obstructions should be avoided.

In consideration of the above the following design considerations are recommended for the implementation of islands:

- PRI on roads with volumes below 45,000 AADT
- Clear lines of sight between the pedestrian and driver
- Parking restrictions and access control
- Far side bus stop locations
- Adequacy of sight lines due to road geometry or street furniture

ROAD ALIGNMENT DESIGN CONSIDERATIONS

Road alignment is a key aspect of driver guidance. Where a tangent road alignment exists for some distance, there is a degree of expected continuity of that alignment by the driver. Localized road widenings are often implemented in order to accommodate a pedestrian island. These widenings can result in a shift of the road alignment, resulting in the vehicle path being directed toward the island. When the widening of the road is taken on one side of the road only, the alignment shift is most severe. The driver must rely on other visual queues such as signage and pavement markings to recognize the change in the path of the roadway.

The transition taper approaching the island controls the rate of shift in the lane alignment. The longer the taper is, the more gradual the alignment shift will be. This may be affected by the length of any necessary road widening. Road widenings are typically comprised of 36 feet through the length of the island, 16 foot long tangent sections approaching the island and 100 foot long tapers on either side. The widenings vary depending on site conditions, however 3 m widenings are common (representing a taper ratio of 17:1 for roads widened on both sides of the road).

The handrailing is placed on the island within the travelled portion of the road right of way. As such, the handrail represents a significant obstacle within the roadway. The railings are not highly visible, since they run parallel to the direction of approaching vehicles. Handrails add to the need to provide good road alignment conditions.

To minimize the effects of undesirable road alignments in proximity to pedestrian islands, the following design alternatives should be considered:

1. If sufficient road width is available, introduce pedestrian islands without widening the road
2. In order to provide consistent lane alignment, the option of introducing a continuous centre left turn lanes on four lane roads, and incorporating the island within the centre left turn lane is preferred

3. If a road widening is considered further as means of accommodating pedestrian island, the transition tangent section approaching the island should be maximized and widening should be balanced on both sides of the road
4. The setback of islands and railings from the travelled portion of the roadway should be maximized. A minimum setback of 0.5 metres should be maintained between the travelled portion of the road and the island.
5. Where ideal alignment and setback conditions cannot be maintained, crash cushions should be considered as a form of end treatment.
6. Where railings cannot be adequately setback from the roadway, or ideal alignment cannot be maintained, and an end treatment is not feasible, then the appropriateness of the railings and the island itself should be reconsidered.

VISIBILITY

Pedestrian refuge islands have been hit by vehicles almost exclusively at night. They have less illumination than split pedestrian crossovers, and the collision results imply that the PRI could benefit from improved visibility and possibly illumination.

For pedestrian refuge islands, particularly where other aspects of the road alignment or environment are not ideal, the following options should be considered:

1. Situate the island directly below an existing street light
2. Provide supplementary illumination, illuminated end signs, or high intensity signs
3. Use wider/larger end signs

ACCESSIBILITY ISSUES

Considerations of design and safety should recognize the needs of a cross-section of the population. Users of the roadway include those with mobility disabilities, those who travel with the aid of canes, wheel chairs, and scooters as well as parents with strollers. Approximately 1% of the island users have some visible form of disability. The design of crossings should address the physical requirements of these users.

City of Toronto accessibility references¹ identify spatial envelopes, surface conditions and ramp requirements to accommodate those with special mobility needs. Typical criteria include 5 foot minimum width for pedestrian ways, 10:1 maximum drop curb ramp, and uniform surface texture.

The existing island design provides uniform surface texture, and is wide enough to accommodate the minimum requirements for a wheelchair turning radius. If the standard 6 inch curb height is provided, it would require 60 inches or 5 feet of ramp to maintain the 1:10 ratio. It appears as though the majority of islands meet the 1:10 ratio. However efforts to minimize the effects of ramps should be considered further.

TRAFFIC CONTROL

A high number of rear end collisions occur at split pedestrian crossovers. The SPXO is a less common form of traffic control than traffic control signals. As previously noted, vehicles did not

appear to act uniformly approaching a split pedestrian crossover. In terms of road right of way rules, it is unclear what degree of understanding drivers have. Drivers at SPXO's may not know when to stop or if vehicles in front or behind will stop.

Investigations into the effects of advance yield markings have proven to be effective at crosswalks². The advance warning communicates to drivers through signage and markings where to stop when a pedestrian is crossing, and reinforces the need to stop. The location of the markings and signs can also provide greater separation between the yielding vehicle and the pedestrian. This advance warning signage and markings could be directly applied to split pedestrian crossovers. The following advance warning applications should be considered for pedestrian crossovers:

- "Yield here to pedestrians" signage
- yield markings (triangles 16" wide by 24" long separated by 9")
- locate 30 to 50 feet in advance of the crossing

SUMMARY

Both the pedestrian refuge island and split pedestrian crossover islands add to the convenience and comfort for pedestrians crossing major roads. These road elements have the potential for enhancing safety and reducing collisions if implemented under the appropriate conditions. There are specific operational issues that require consideration prior to implementation. A development of a design guide is recommended to summarize the preferred road environment, alignment, island visibility, accessibility, and traffic control measures. The next step in the audit process is a detailed site by site review of how existing islands conform to recommended roadway and island characteristics.

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